## Cerebral Flow Studies Done with Brain Scan

THE RADIOACTIVE TRACERS normally used in static brain scanning do not cross the intact blood brain barrier; they distribute in the venous pool and extracellular spaces (that is, not normally in the brain substance). They nonspecifically delineate any abnormality that causes blood brain barrier breakdown by accumulating in the brain substance. The one most commonly used is $^{99m}$-technetium ($^{99m}$Tc) pertechnetate. Most supratentorial and posterior fossa tumors, cerebrovascular accidents at least several days after clinical onset and chronic subdural hematoma are well delineated with this technique.

Cerebral flow studies have been shown to enhance brain scanning by adding a hemodynamic evaluation. This procedure is often referred to as cerebral radionuclide angiography (CRAG). The study employs the same radiopharmaceutical dose administered for the subsequent brain scan. The dose is injected rapidly into a large peripheral vein with the patient's head placed either directly in front of a scintillation camera to view both neck and cranial vasculature or only the cranial vasculature in a vertex projection.

The dynamics of radioactivity distribution can be depicted by multiple, sequential polaroid film images made approximately every two or three seconds following injection. Alternatively, more elaborate processing of data can be done with a minicomputer data analysis system to assess objectively the vascular asymmetry. Because nondiffusible tracers are used, no absolute measurements (such as ml per gram per minute) of flow are determined.

From the clinical diagnostic standpoint six useful patterns of this flow study can be observed: (1) an abrupt intracranial "hot spot," at the onset of the arterial phase, which rapidly fades—arteriovenous malformation; (2) slightly less abrupt "hot spot" that persists well into the venous phase—meningioma; (3) focally decreased area in the internal or common carotid artery with symmetrical activity in the middle cerebral artery (MCA) distributions—extracranial vascular occlusion with adequately functioning circle of Willis; (4) decreased activity in one MCA area that subsequently does not fill in—intracerebral tumor or hematoma; (5) decreased activity in one MCA area that subsequently fills in either due to prolonged transit time or to collateral flow—cerebral vascular accident (frequently seen *before* the brain scan becomes "positive"), and (6) decreased activity along one or both cerebral convexities—subdural hematoma (seen with acute subdural even *before* the brain scan becomes "positive").

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## Thyroid Cancer Following Juvenile Neck Irradiation

### *—A New Role for Thyroid Imaging*

IN 1973, DEGROOT AND PALOYAN reported "a Chicago endemic" of postirradiation thyroid cancer. The report had some disturbing disclosures, including the fact that in 20 percent of their patients with malignant tumors findings were normal on isotope thyroid scans. They found the isotope scan of minor utility and suggested that any palpable nodule should be considered suspect in a patient with history of thyroid irradiation, even if the nodule was not detectable on scan.

Now, Arnold and co-workers report that in patients with a history of neck irradiation, *nonpalpable cold nodules can be detected by radionuclide imaging*. These nodules have about a 20 percent probability of maligancy. Arnold studied a large group of patients (almost 1,500) whose primary reason for referral was a history of childhood neck irradiation and he used radioactive technetium ($^{99m}$Tc) pertechnetate in combination with a gamma camera to produce very high resolution thyroid images. Arnold's findings destroy another common concept about thyroid cancer. In the irradiated group, the incidence of malignancy in patients with multiple nodules (39 percent) was virtually the same as in patients with single "cold" nodules (33 percent).

Traditionally, virtually all thyroid cancer was thought to present as isotopically cold nodules, and the value of an isotope scan was to confirm that the palpable nodule was cold and solitary. Multiple nodules were felt to be a sign of be-

nignity. These concepts are now under vigorous attack.

Many forms of thyroid cancer have a relatively benign clinical course even if untreated, and there is still enough controversy regarding the pathologic differentiation of benign from malignant tumors to provide traditionalists with ammunition to defend older attitudes. To date no patient who has had thyroid cancer detected as a result of postirradiation screening tests has died of the disease. However, the most conservative approach is to treat many of the classic concepts about thyroid cancer with skepticism, especially in patients who have received radiation in childhood. Palpation, scintiphotographs and thyroid function tests are indicated in all persons with history of such irradiation. Either a palpable nodule *or* nonpalpable "cold" area on scintiphoto is sufficient indication to at least consider surgical operation. If all thyroid studies give normal findings, treatment with replacement doses of thyroxine may provide some protection against future tumor development.

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## Abnormal Brain Scan Findings Resulting from Prior Electroencephalograms

A BRAIN SCAN and an electroencephalogram are used often in combination to evaluate patients with neurologic symptoms. When these two modalities are required, the brain scan should be done first.

Much of the cranial activity seen on a brain scan results from radionuclide accumulation in the extracellular fluid of the scalp and skull. The minimal scalp irritation associated with the application of electroencephalographic electrodes with electrode glue has been reported to result in a local increase in extracellular fluid concentration and a corresponding increase in activity on the brain scan. In the preceding twelve months at the University of California, San Diego, we have also observed abnormal brain scan findings following an electroencephalogram. The sites of abnormal accumulation were located peripherally and repeat scans several days later gave normal findings.

In summary, because an electroencephalogram may result in minor scalp trauma and localized radionuclide accumulation, a brain scan should be carried out first. When an electroencephalogram is done before the brain scan, the nuclear medicine physician concerned should be made aware of the electroencephalogram and the brain scan should be delayed, if possible, at least 48 hours.

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## Gallium-67 Tumor Imaging

SINCE 1969, scanning with gallium-67 as the citrate has gained wide use, although its acceptance as a routine test in nuclear medicine is still limited because of the variability of uptake in bowel, liver, spleen and bone marrow and the nonspecificity of gallium for tumor.

In tumor evaluation gallium has found its greatest success in the detection and staging of lymphomas. The accuracy in detection of involved sites in Hodgkin's disease has been reported as 65 to 79 percent. The information from gallium scans and lymphangiograms is complementary. Efficacy above the diaphragm is better than below. Non-Hodgkin's lymphoma has a somewhat poorer detection rate and uptake seems to depend on the histocytic component.

Other tumors with high affinity to gallium citrate include bronchogenic carcinomas where mediastinal involvement may be detected while findings on x-ray studies are still normal. Melanoma detection has been evaluated in several institutions and found to be good in lesions larger than 2 cm. Gallium uptake in hepatoma may also be high with a reported detection rate of 70 to 90 percent.

Other tumors show greater variability in uptake even within tumor types. Adenocarcinomas are generally not well detected. Head and neck tumor evaluation has been moderately successful.